Transportation of Snake River Fall Chinook Salmon 2008:
Final Report for the 2004 Juvenile Migration

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Report of research by

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Walla Walla, Washington 99362-1876
Delivery Order E86960099

June 2010

EXECUTIVE SUMMARY

The National Marine Fisheries Service began annual studies in 2001 to evaluate the efficacy of transporting Snake River fall Chinook salmon *Oncorhynchus tshawytscha* smolts from Lower Snake River hydropower projects. From 2001 through 2003, we tagged hatchery subyearling fall Chinook salmon at Lyons Ferry Hatchery and released them 81 km above Lower Granite Dam at Snake River kilometer 254. In 2004, this tagging routine was interrupted due to a lack of available subyearling fall Chinook salmon at Lyons Ferry Hatchery. Instead, we tagged river-run fish at Lower Granite Dam in 2004. During September and October 2004, we also tagged a fall transport index group of subyearling Chinook salmon (no fish were released to migrate inriver) for the third year at Lower Granite Dam. Final adult returns from tagging in both summer and fall 2004 are reported here. Results from 2001-2003 have been reported and are summarized and cited here in Appendix B.

Our original study was designed to compare smolt-to-adult return rates (SARs) of fish transported as juveniles from Lower Granite Dam with those of fish released to migrate inriver and not detected at any collector dam. However, recent data has shown the model used to estimate numbers of nondetected fish in studies using spring Chinook salmon cannot be used for Snake River fall Chinook salmon. This model relies on the assumption of equal probabilities of detection for fish from each cohort. However we now know that some fall Chinook delay their downstream migration for several months, passing dams during the winter when bypass systems are dewatered. Thus, since there is no way to reliably estimate numbers of nondetected fish, we report only the SARs of fish with known passage histories from the fish initially released.

Known passage histories of subyearling Chinook include those of transported fish, fish detected and bypassed as subyearlings in 2004, and fish detected migrating the year following release (holdover fish). From August to November 2008, we detected four age-4-ocean adults that had been transported from Lower Granite Dam in 2004, one adult that had been detected during spring 2005 (holdover), and five age-4-ocean adults from the transport index group marked in September-October 2004. The adults returning in 2008 complete adult returns from smolts tagged during the 2004 study year. Total adult returns from the summer marking at Lower Granite Dam in 2004 were very poor; only 20 adults returned to Lower Granite Dam for the 3 test groups.

For the combined age classes of subyearling fish tagged during summer 2004 (jacks through age-4-ocean fish), SARs were 0.14% (95% CI, 0.02-0.26%) for transported fish, 0.10% (0.04-0.17%) for bypassed fish, and 2.22% (0.04-4.40%) for holdovers. The SAR for the fall transport index group was 1.89% (1.35-2.42%).

For the combined year-classes of fish tagged as juveniles in June and July 2004, adult conversion rates between Bonneville and Lower Granite Dam were 83.3 (5 of 6 fish) for transported fish, 45.0 (9 of 20 fish) for bypassed fish, and 57.1% (4 of 7 fish) for holdover fish (rates not adjusted for harvest). For the fall transport index group, the overall conversion rate was 54.0% (47 of 87 fish), and of the fish not arriving at Lower Granite, up to 23% did not convert from McNary to Lower Granite Dam, while the loss between Bonneville and McNary Dams ranged from 17 to 45%. The lower river stretch has the Zone 6 Native American fishery. Too few adults returned to make meaningful comparisons of conversion rates among treatment groups.

Median travel times of adults from transport, bypass, and holdover groups ranged from 12 to 14 d, while the fall transport index group had a median travel time of 15 d.

Results from the small number of returning adults from 2004 transportation study releases did not provide definitive information change the conclusion of Williams et al. (2005) (based on earlier study years) that "transportation appeared to neither greatly harm nor help" Snake River fall Chinook salmon. The transported group had slightly higher SARs than the bypassed group in 2004. The highest SARs were seen in fish that delayed migration until fall or held over and migrated the following year as yearlings.

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INTRODUCTION

In 2008, we continued annual studies that began in 2001 to evaluate transport of juvenile salmonids as a means to mitigate for downstream losses that result from passage through the lower Snake and Columbia River federal hydropower system. The U.S. Army Corps of Engineers funds annual transportation studies to inform management decisions on which operational strategies are most likely to maximize numbers of returning adults. Thus, to assess transportation as a mitigation tool, we compare smolt-to-adult return rates (SARs) of juvenile Snake River fall Chinook salmon *Oncorhynchus tshawytscha* transported to a release site below Bonneville Dam to those of their cohorts that migrated inriver through the hydropower dams. Detections of inriver migrant PIT-tagged smolts also provided data for short-term survival estimates between the point of release and downstream dams (Muir et al. 2001).

We originally designed the fall Chinook salmon transport studies to compare SARs of fish transported from Lower Granite Dam with those of fish that were not detected at any collector dam. However, recent data (Conner et al. 2005) has shown that the model used to estimate numbers of non-detected spring inriver migrants (Sanford and Smith 2002) is not appropriate for estimating the number of non-detected Snake River fall Chinook salmon. A critical assumption of the model used to estimate juvenile survival is violated when some fall Chinook delay downstream migration (Buchanan and Skalski 2006). Estimates of juvenile survival based on this model consider the joint probability of migration and survival; however, for fall Chinook salmon, the probability of migration is unknown. These juveniles may migrate throughout the year, but detection systems at the dams are not operated year-round; fish that migrate when detection systems are not operated have no possibility of detection, thus no data on migration probability is available (Buchanan and Skalski 2006).

Because at present there is no method to estimate the number of non-detected fall Chinook salmon, we report SARs only for fish with known passage histories. These include fish transported and bypassed in the year of their release (2004) and holdover fish, which may be detected during migration in the year following release (2005). In a related effort, we also PIT-tagged a fall transport index group of subyearling Chinook salmon collected at Lower Granite Dam during September and October 2004. This was the third year of tagging to develop a fall transport index of SARs. As in the previous two years, all transport index fish were loaded to trucks along with non-tagged river-run fish, and no concurrent group of inriver migrant PIT-tagged fish was released to the tailrace. Thus, there is no comparison group for this fall transport group, and they provide only an index of SARs for fish transported in the fall.

The more complex life history of Snake River fall Chinook salmon also precluded us from making estimates of differential delayed mortality (*D*) because insufficient data is available to estimate survival to the tailrace of Bonneville Dam for Snake River fall Chinook; a value needed to estimate *D*.

Here we report final results from the 2004 Snake River fall Chinook salmon tagging year, which was completed with the recovery of adults in 2008. Complete adult return information from earlier study years (2001-2003) has been reported (Marsh et al. 2008, in press) and is summarized here (Appendix B) along with returns to date from ongoing transport studies of fall Chinook salmon (2005-2007).

For Snake River fall Chinook salmon smolts PIT-tagged for transport studies during 2008, adult return data are not yet available. Data from these returns will be included in annual fall Chinook transport study reports beginning with the first returns of these adults in 2009. Results will be reported in full when adult returns from releases in 2008 are complete in 2012.

METHODS

Juvenile Collection and Tagging

For transportation studies of subyearling fall Chinook salmon, we tagged surrogate fish at Lyons Ferry Hatchery from 2001 through 2003. Surrogates differ from production hatchery fish in that they are raised to be released at the size of smaller, wild subyearling Chinook salmon. However, in 2004, surrogate-sized Snake River fall Chinook salmon juveniles were not available for tagging and release. Therefore, we tagged river-run subyearlings at Lower Granite Dam during June and July 2004.

During the month of June, fish were PIT tagged at Lower Granite Dam in the same tagging trailer that we use to mark fish for spring transport studies. Basic collection and handling, including the use of the re-circulating anesthetic water system, followed the methodology described by Marsh et al. (1996, 2001). Tagged fish for the transport group were put into raceways before subsequent loading into barges, while fish for the inriver migrant group were sent to a holding tank after tagging and released the following day.

At the end of June, tagging operations were moved into the Lower Granite Dam juvenile fish facility laboratory due to a decrease in the number of juveniles available. We tagged fish taken from the facility daily sample. With transport from the facility occurring every other day, fish for the transport group were either sent to a holding tank near the lab or loaded directly onto the barge, depending on whether it was a transport day or not. Inriver migrant fish were hauled in 20 L carboys and placed in the same holding tanks used when tagging at our tagging trailer and released the following day.

Sample size calculations to evaluate transport SARs relative to inriver migrant SARs (T/Is) were based on determining precision around the estimated T/I such that one-half the width of a confidence interval on the true T/I would not contain the value 1, or the confidence interval on the true natural-log-transformed T/I, ln(T/I), would not contain 0. Therefore, for a desired α and β and specified true T/I, the number of fish needed were determined in the following manner.

T/I is needed such that:

$$\ln \frac{T}{I} - \quad t_{\frac{\alpha}{2}} + t_{\beta} \quad \times SE \quad \ln \frac{T}{I} \quad \approx 0$$

and

$$SE\left(\ln\frac{T}{I}\right) \approx \sqrt{\frac{1}{n_T}+\frac{1}{n_I}} = \sqrt{\frac{2}{n}}$$

where $n_T = n_I = n$ is the number of adult returns per treatment (n_T for transport and n_I for inriver migrant groups set equal for simplicity). The previous two statements imply that the sample of adults needed was:

$$n \approx 2\left(\frac{t_{\frac{\alpha}{2}} + t_{\beta}}{\ln\left(\frac{T}{I}\right)}\right)^2$$

Setting α = 0.05, β = 0.20 and an expected transport SAR of at least 1.0%, sample sizes needed to detect a T/I of 2.0 at Lower Granite Dam are listed below (N denotes the number of juveniles):

$$\begin{aligned} \frac{T}{I} &= 2.0 \\ n &= 34 \\ N_T &= 3{,}400 \\ N_I = NT \times \frac{T}{I} &= 6{,}800 \\ N_{total} &= 10{,}200 \end{aligned}$$

Based upon previous PIT-tag detections, we estimated that 15-30% of the subyearling Chinook salmon released at Lower Granite Dam would never be subsequently detected at a downstream Snake River collector dam. Therefore, to ensure an adequate number of non-detected inriver-migrant fish, we planned to release 45,333 (6,800/0.15) PIT-tagged subyearling Chinook into the Lower Granite Dam tailrace.

River Migration Conditions

Flows at Lower Granite Dam were below the 1994-2003 ten-year average during summer 2004, and no summer spill was provided. At all four collector dams (Lower Granite, Little Goose, Lower Monumental, and McNary Dams), fish detected on coils leading to the raceways were assumed to have been transported (unless records showed otherwise), while fish detected on diversion system coils were assumed to have been returned to the river.

Fall Transport Index

For the third consecutive year, we tagged additional subyearling Chinook salmon in September and October to develop an index of SARs for fish transported in fall. For this separate, but related evaluation, we PIT-tagged and released river-run subyearlings at Lower Granite Dam. These fish were taken from the daily smolt monitoring sample. After tagging, we placed fish with the general population collected at the facility for transport by truck to a release site below Bonneville Dam. We observed no mortality and only one shed tag from these fish, although post-tagging holding time was very short (< 1 h). This index is being developed because numbers of adult fish detected from summer releases have been insufficient to obtain a statistically reliable SAR estimate for fish transported in fall.

Adult Recoveries and Data Analysis

In 2008, we completed the recovery of age-4-ocean adults tagged as juveniles in 2004. We expect very few if any age-5-ocean adults (none returned from 2001 releases) from subyearling fall Chinook tagged in 2004. Therefore, we completed the analyses for 2004 releases of fall Chinook salmon for transport studies after these age-4-ocean adults returned. Analyses were based on SARs of juveniles tagged at Lower Granite dam and subsequent adults that returned to Lower Granite Dam.

RESULTS

Juvenile Collection and Tagging

From 3 June through 31 July 2004, we PIT tagged a total of 49,287 subyearling Chinook salmon at Lower Granite Dam. Of these fish, we released a total of 48,904, with 45,296 released into the tailrace to migrate in the river and 3,608 loaded into barges at the dam (Table 1 and Appendix Table A1). An additional 2,544 fall Chinook salmon were collected at Lower Granite Dam in September and October, PIT-tagged, and transported by truck to below Bonneville Dam (Table 2 and Appendix Table A2).

Based on mortality counts, post-marking delayed mortality (24-hour) averaged 0.6% over the June-July (summer) tagging season. In addition to the mortalities, there were 84 shed tags (0.2%).

Table 1. Numbers tagged, released, and mean fork lengths of subyearling fall Chinook salmon PIT-tagged at Lower Granite Dam and released as part of the Snake River fall Chinook salmon transport study, 2004.

	Number	Mean fork length (mm)
Transport		
Tagged	3,622	103.8
Released*	3,608	103.8
Inriver migrant		
Tagged	45,665	104.1
Released*	45,296	104.1

* Release numbers adjusted for mortality and tag loss. In addition, nine fish that were supposed to have been transported from Lower Granite Dam were detected at one or more dams below Lower Granite Dam and were removed from the transport release group.

Table 2. Tag date, numbers tagged, and mean fork lengths of fish PIT-tagged at and transported from Lower Granite Dam to determine an index SAR for Snake River fall Chinook salmon transported in September/October 2004.

	Lower Granite Dam Fall Chinook salmon	
Tag date	Number tagged	Mean fork length (mm)
9/15/04	101	157.2
9/17/04	330	162.9
9/21/04	321	164.9
9/23/04	250	164.4
9/29/04	110	167.8
10/1/04	41	170.4
10/5/04	117	172.1
10/7/04	242	174.0
10/13/04*	126	170.1
10/15/04	123	175.1
10/19/04	152	172.5
10/21/04	146	171.0
10/27/04	326	169.1
10/29/04	160	171.3

* One fish shed its tag making the release number for this date 125.

Migration Histories

Of the 45,296 fish released into the tailrace of Lower Granite Dam 11,884 (26.2%) were never detected at a collector dam after release. The remaining 33,412 fish had various detection histories at downstream dams (Table 3 and Appendix Tables A3-A6). Fish tagged at Lower Granite Dam for the fall transport index group were only seen at marking (Table 3).

Table 3. Summary of detection histories of river-run fall Chinook salmon smolts PIT-tagged at Lower Granite Dam and released into the tailrace, 2004.

Migration history	Detection history	Total number	Number of detections			
			First	Second	Third	Fourth
Not detected[a]	ND	11,836	--	--	--	--
Bypassed[b]	R	8,898	5,670	2,541	687	--
Transported from:						
Little Goose Dam	T-LGS	17,269	15,670	--	--	--
Lower Monumental Dam	T-LMN	4,748	1,971	2,777	--	--
McNary Dam	T-MCN	2,038	773	1,001	264	--
Unknown	U	271	208	59	4	--
Holdovers:						
Not detected[a]	H-ND	87	71	16	--	--
Bypassed[b]	H-R	123	80	37	6	
Bypassed[b]	H-R2[c]	22	--	19	2	1
Lower Monumental Dam	H-T-LMN	4	2	2	--	--
Fall transport index	Fall-T	2,544	2,544	--	--	--

a "Not detected" means not detected at a collector dam below Lower Granite Dam (Little Goose, Lower Monumental, or McNary Dams). These fish could have been detected at other locations (Ice Harbor, John Day, or Bonneville Dams or the PIT trawl in the estuary or McNary Dam during the spring).

b "Bypassed" means returned to the river after being detected at one or more of the collector dams below Lower Granite Dam (Little Goose, Lower Monumental, or McNary Dam during summer and fall; Lower Granite, Little Goose, or Lower Monumental during spring).

c These fish were detected at one or more of the collector dams below Lower Granite Dam (Little Goose, Lower Monumental, or McNary Dams) as subyearlings during summer and fall 2004, and detected again as yearlings during spring 2005.

Our goal was to use the separation-by-code (SbyC) systems to divert 80% of the subyearling Chinook salmon collected to transportation raceways at both Little Goose and Lower Monumental Dams. Unfortunately, the total proportions of subyearling Chinook salmon collected and diverted for transport were only 59.3% at Little Goose and 56.7% at Lower Monumental Dam. These results were not due to poor performance of PIT-tag diversion systems but to human error: PIT Tag Operations Center staff forgot to implement the SbyC systems at both dams.

Prior to implementation of the SbyC systems, virtually all of the 6,478 and 1,957 study fish detected at Little Goose and Lower Monumental Dams, respectively, were returned to the river. After implementation of the SbyC at mid-morning on 14 June 2004, 75.9% of the 22,628 study fish detected at Little Goose Dam and 72.3% of the 6,414 study fish detected at Lower Monumental Dam were diverted to transport. We had also planned to transport 80% of the study fish from McNary Dam. However, collection for transport at McNary Dam did not start until 0700 PDT on 23 June 2004, by which time, most (98.6%) of our study fish had passed this dam. After collection for transport began, 65.2% of study fish detected were diverted to transport.

Adult Recoveries and Data Analysis

We began recovering jacks from the 2004 releases at Lower Granite Dam in 2005. In November 2008, we completed recoveries from this release year with the collection of age-4-ocean adults. Final results by study group and age-class are presented in Table 4. As shown in Table 4, considerably more fish returned from the fall transport index group than from the summer transport group.

Table 4. Hatchery fall Chinook salmon returns by study group and age-class used to evaluate transport from Lower Granite Dam in 2004. Juvenile numbers are actual counts.

	Returns by age-class						
Juvenile numbers	Jack	2-ocean	3-ocean	4-ocean	5-ocean	SAR (%)	95% CI
Transported from Lower Granite Dam							
3,608	1	0	0	4	-	0.14	(0.02-0.26)
Bypassed at collector dams							
8,898	3	1	0	0	-	0.04	(0.00-0.09)
Holdovers (transports and inriver migrants combined)							
236	0	2	3	1	-	2.54	(0.51-4.58)
Fall transport index							
2,544	13	14	16	5	-	1.89	(1.35-2.42)

Smolt-to-Adult Return Rates

The trend of poor SARs for fish migrating during the summer transport season continued for fish marked during June-August 2005. The temporal pattern of adult return was similar to past years, where later migrating fish usually had higher SARs. There were too few adult returns for more in-depth analysis (Figure 2). We also could not determine the original number of fish from the initial population released that were "destined for transport."

Daily SARs ranged from zero to 3.4% for river-run fall Chinook salmon tagged at Lower Granite Dam during September and October 2004 (Figure 3). The overall SAR, 1.89%, was the lowest to date for this group. Daily SARs showed a trend of increasing survival to adulthood with later date of juvenile tagging over the course of the fall 2004 study period.

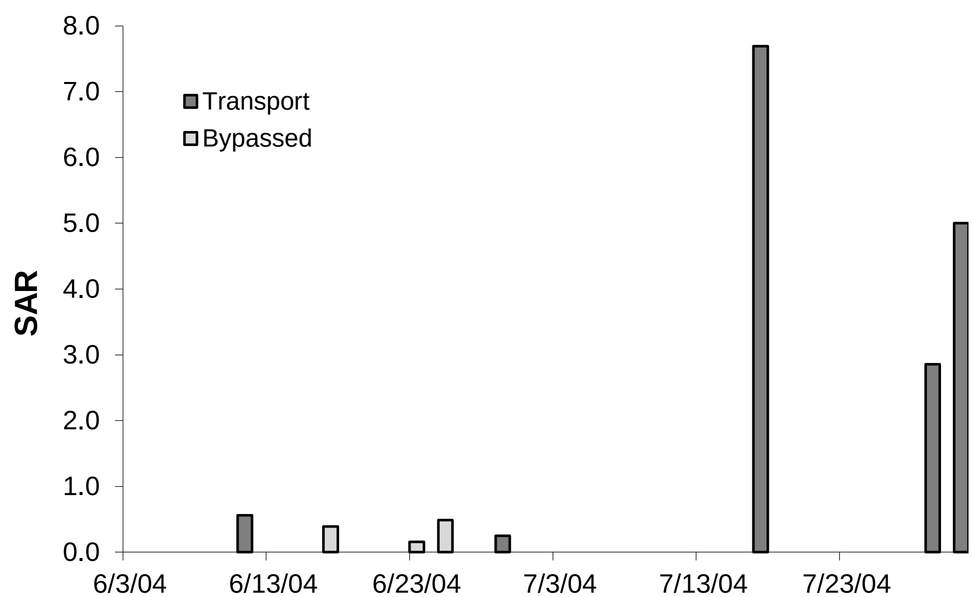

Figure 2. Smolt-to-adult return rates (SARs) by passage date at Lower Granite Dam for subyearling Chinook smolts tagged in 2004 at Lower Granite Dam. Data are daily SARs.

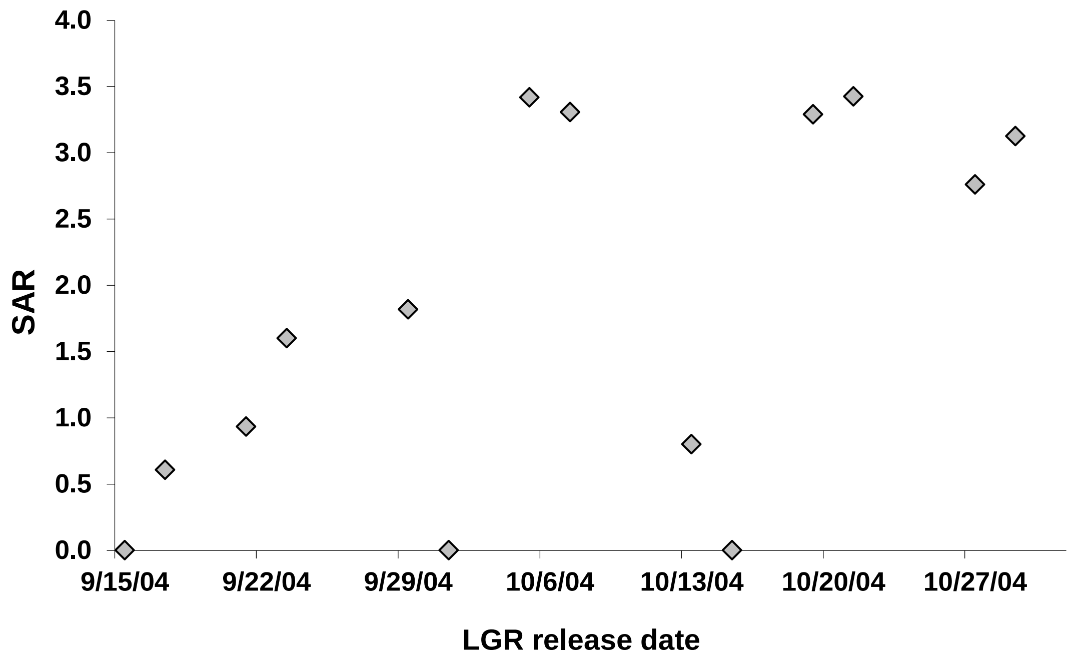

Figure 3. Smolt-to-adult return rates (SARs) for fall transport index fish by tag date. River-run subyearling Chinook smolts tagged in fall 2004 at Lower Granite Dam and transported by truck to below Bonneville Dam. Data are daily SARs.

Conversion Rates

We could make no meaningful comparisons among conversion rates for transported, bypassed, and holdover fish tagged in summer 2004 because of the low number of adult returns (Table 6). We did observe a low conversion rate for the 2004 fall transport index group (Table 6), although the conversion rate for these fish was higher than that observed for fall transport index fish in previous marking years. Except for jacks, the conversion rate for fall transport index fish between Bonneville Dam and McNary Dam was lower than the conversion rate between McNary Dam and Lower Granite Dam (Table 7). This was expected, given the harvest pressure in the Zone 6 fishery (for which these numbers were not adjusted). The older the fish (and hence the larger the fish), the lower the conversion rate between Bonneville and Lower Granite Dams. This is likely due to the large mesh nets used in the Zone 6 fishery (to allow steelhead *O. mykiss* escapement).

Table 6. Percentage of adult Lyons Ferry Hatchery and river-run fall Chinook salmon PIT-tagged in summer and fall 2004 that were observed at Bonneville Dam and subsequently detected at Lower Granite Dam (the conversion rate).

	Number seen at Bonneville Dam	Number seen at Lower Granite Dam	Conversion rate
	Jacks		
Bypass	3	3	100.0
Transport	1	1	100.0
Holdover	1	0	0.0
Fall transport index	19	12	63.2
	Age-2-ocean adults		
Bypass	4	1	25.0
Transport	0	0	--
Holdover	2	2	100.0
Fall transport index	18	14	77.7
	Age-3-ocean adults		
Bypass	9	5	55.6
Transport	0	0	--
Holdover	2	1	50.0
Fall transport index	28	16	57.1
	Age-4-ocean adults		
Bypass	4	0	0.0
Transport	5	4	80.0
Holdover	2	1	50.0
Fall transport index	22	5	22.7
	Totals		
Bypass	20	9	45.0
Transport	6	5	83.3
Holdover	7	4	57.1
Fall transport index	87	47	54.0

Table 7. Adult conversion rate (percent) from Bonneville Dam to McNary Dam and from McNary Dam to Lower Granite Dam for river-run fish tagged for fall transport index in 2004 (no adjustment for Zone 6 harvest.)

	Bonneville Dam to McNary Dam			McNary Dam to Lower Granite Dam		
Migration history	Seen at Bonneville (n)	Subsequently seen at McNary (n)	Conversion rate	Seen at McNary (n)	Subsequently seen at Lower Granite (n)	Conversion rate
Jacks	19	16	84.2	17	13	76.5
Age-2-ocean	18	15	83.3	15	14	93.3
Age-3-ocean	28	18	64.3	18	17	94.4
Age-4-ocean	22	5	22.73	5	5	100.0
Totals	87	54	62.1	55	49	89.1

To understand the lower conversion rate of fall transport adults, we looked at straying; however, the only two fish (one jack and one age-3-ocean adult) that strayed were fish that had been released into the tailrace of Lower Granite Dam and transported from Little Goose Dam. Both strays crossed Priest Rapids Dam, and one continued up the Columbia River and crossed Rock Island Dam (Table 8). Neither of these two fish returned to the Snake River.

Table 8. Adult detection data for fall Chinook salmon strays returning from the 2004 study year. Both fish were released to Lower Granite Dam tailrace and transported from Little Goose Dam. Both fish strayed past the confluence of the Columbia and Snake Rivers.

	Adult detection date at Columbia River dams				Adult detection date at Snake River dams	
Tag code	McNary	Priest Rapids	Rock Island	Wells	Ice Harbor	Lower Granite
3D9.1BF2035BA6	9/17/05	9/23/05				
3D9.1BF1A6E31C	7/31/07	8/10/07	8/15/07			

We also looked at median travel time as a possible reason for the differences in conversion rates between transport study fish tagged in summer and fall transport index fish tagged in fall 2004. The total median travel times of the four groups (all age classes combined) ranged from 12 to 15 d (Table 9). We do not believe that a difference of only three days would explain the differences in conversion rates.

Table 9. Travel times from Bonneville Dam to Lower Granite Dam for adult fall Chinook salmon PIT-tagged as juveniles in 2004.

Age class	Migration history	Number of adults	Travel time from Bonneville Dam to Lower Granite Dam (d)
Jacks	Bypass	3	13.0
	Transport	1	12.0
	Holdover	0	--
	Fall transport index	12	14.5
Age-2-ocean	Bypass	1	8.0
	Transport	0	--
	Holdover	2	10.5
	Fall transport index	14	13.5
Age-3-ocean	Bypass	5	12.0
	Transport	0	--
	Holdover	1	19.0
	Fall transport index	16	19.5
Age-4-ocean	Bypass	0	--
	Transport	4	14.0
	Holdover	0	--
	Fall transport index	5	32.0
Totals	Bypass	9	12.0
	Transport	5	14.0
	Holdover	4	13.5
	Fall transport index	47	15.0

Length at Tagging

With the low number of adult returns, and no transport adults in two of the four years, it was not possible to compare size at tagging between bypass, transport, and holdover groups from 2004 transport study releases (Table 10).

Table 10. Average tagging lengths of adult hatchery and river-run fall Chinook salmon PIT-tagged as juveniles at Lower Granite Dam during June and July 2004.

Age class		Number of adults	Average length as juveniles at tagging of returning adults (mm)
Jacks	Bypass	5	108.0
	Transport	1	94.0
	Holdover	0	--
Age-2-ocean	Bypass	1	100.0
	Transport	0	--
	Holdover	2	106.0
Age-3-ocean	Bypass	5	99.2
	Transport	0	--
	Holdover	1	108.0
Age-4-ocean	Bypass	0	--
	Transport	4	109.0
	Holdover	1	100.0

Effects of 2004 Tagging at Lower Granite Dam on Study Results

Despite our inability to procure hatchery fish for tagging in 2004, hatchery production subyearlings still made up the bulk of the subyearling juvenile migration, with 1.7 million hatchery fish released (1.5 million with no adipose fin clip). We believe that a majority of the fish tagged at Lower Granite Dam during summer 2004 were hatchery production fish. Because production-sized hatchery fall Chinook salmon juveniles have a compressed, early migration, we expected that very few of these fish would be detected migrating in spring 2005. In addition, fish were collected at the dam for the 2004 tagging, meaning they were most likely actively migrating at that time. This further reduced our expectation that any would be detected the following spring.

However, of the fish tagged and released into Lower Granite Dam tailrace in 2004, 0.52% were detected during spring 2005. This was more than five times the holdover rate of production fish tagged in 2003 for this study (Table 11). Since this was the first time we had tagged subyearlings at Lower Granite Dam for a transport study, we examined the data for possible explanations for this difference.

Table 11. Percentages of juvenile hatchery and river-run fall Chinook salmon migrating the year after release from above or at Lower Granite Dam, 2001-2008.

		Holdover rate for subyearling Chinook salmon (fish detected migrating as juveniles one year after release)				
Study year	River of release	Production subyearlings	Surrogate subyearlings	Yearlings	Summer river-run*	Fall river-run*
2001	Snake	--	0.67	--	--	--
2002	Snake	--	1.24	--	--	--
2003	Snake	0.10	--	--	--	--
2004	Snake	--	--	--	0.52	--
2005	Snake	--	0.02	--	--	--
	Clearwater	--	1.34	--	--	--
2006	Snake	0.00	0.02	--	--	--
	Clearwater	0.01	0.98	--	--	--
	Grande Ronde	0.03	--	--	--	--
2007	Snake	--	--	--	--	28.64
2008	Snake	0.01	0.08	0.00	--	16.74
	Clearwater	0.07	1.56	0. 00	--	--
	Grande Ronde	0.03	--	--	--	--

* Fish were tagged at and released into the tailrace of Lower Granite Dam

As a first step in examining data that might explain the high proportion of holdovers, we wanted to compare the passage distribution of hatchery production subyearlings to that of our 2004 study fish. This comparison would help identify any temporal patterns in the percentage of holdovers by release date. However, since we could not tag hatchery fish in 2004, these distributions could not be compared until after the 2006 and 2008 tagging years, when we were able to tag fish at the hatcheries. In both these years, hatchery fish were PIT-tagged in representative numbers according to the proportions released at respective hatchery locations in the Snake, Clearwater, and Grande Ronde Rivers. Therefore, we combined all release sites across both years to arrive at an average passage distribution for the comparison.

Using the combined release-site data, averaged for 2006 and 2008, we found that by 12 July (by which time, we had tagged 92% of all our study fish in 2004), 97% of the hatchery production fish would have passed Lower Granite Dam (Figure 4). Thus our belief that prior to 12 July, most tagged fish were of hatchery origin was probably correct. As expected, we found the first five weeks of tagging (through 12 July) produced only 22% of fish detected in spring 2005. If tagging had stopped on 12 July, the holdover rate would have been 0.12%, similar to the 0.10% rate observed in 2003 when only hatchery production fish were tagged. Considering that 42% of the holdovers during this period came from one day (20 June), removal of that day would put the holdover rate in line with the rates observed for 2006 and 2008 production fish.

As Figure 4 shows, there was a strong increasing trend in daily holdover rates over the final three weeks of tagging. Daily rates ranged from 2.7 to 8.5%, with an average daily rate over the last three weeks of 5.3%. With production fish past Lower Granite Dam, the majority of the fish tagged over the last three weeks were most likely natural fish. Our observations of holdover rates support the findings of Connor et al. (2005) that the later a subyearling Chinook salmon migrated, the higher the chances that it will not leave the hydropower system until the following year.

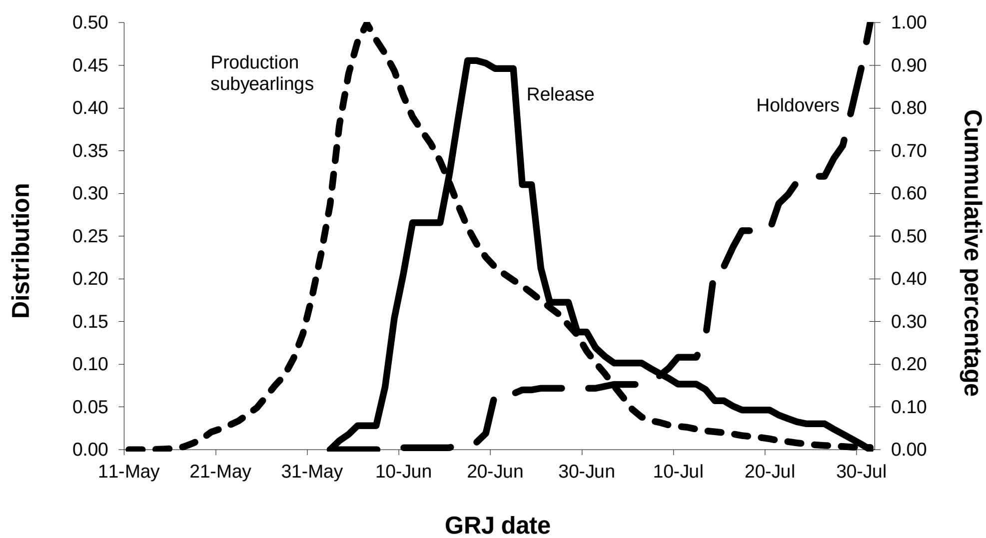

Figure 4. Average passage distribution at Lower Granite Dam for a) hatchery production subyearling fall Chinook salmon (2006 and 2008 data), b) release for 2004 transport study tagging at Lower Granite Dam, and c) cumulative percentage of fish released in 2004 that were detected in the FCRPS in spring 2005 by release date.

DISCUSSION

When we began Snake River fall Chinook salmon transport studies in 2001, we believed that this group of fish had migration behavior similar to that of spring Chinook migrants. That is, they would complete their migration to the ocean during the same year they were tagged and released (Marsh et al. 2008). Based on this assumption, we designed the study for fall Chinook salmon to be similar to studies of spring migrants (Marsh et al. 1997, 2000, 2001, 2004b, 2005, 2006). This approach was to release a transport and an inriver migrant group of subyearling Chinook, intending to compare SARs returning transported adults to those of their non-detected cohorts. In other words, to compare transported fish with fish that migrated as juveniles without being detected at a dam with transport facilities (meaning Lower Granite, Little Goose, Lower Monumental, or McNary Dam).

To estimate numbers of "non-detected" fish in the inriver migrant cohorts, we originally intended to use the methods of Sandford and Smith (2002). In fact these methods were used during fall Chinook transport studies from 2001 to 2004 (Marsh et al. 2003, 2004a). Since fall Chinook salmon can return as adults up to 5 years after entering the ocean, adult returns of these fish would be completed from 2006 to 2009.

However, as we began to observe adult returns from the 2001-2004 releases, we obtained new information about Snake River fall Chinook salmon behavior and their complex life history strategies. An important finding that has affected our study design was the fact that Snake River fall Chinook salmon migrate year-round, often stopping for months at a time before moving farther downstream (Connor et al. 2005; Marsh et al. 2007, 2008, in press). The consequence of this behavior is that we cannot distinguish between the probabilities of detection, mortality, and delayed migration in the non-detected fish group. Therefore, we can no longer base transport studies of Snake River fall Chinook salmon on a study design used for transport studies of spring migrants (spring/summer Chinook salmon and steelhead). In light of these findings, the models used to estimate survival, and consequently size, of the non-detected cohort are inappropriate for subyearling Chinook (Buchanan and Skalski 2006).

For example, a basic assumption of the model that estimates the number of fish that arrived at Lower Granite Dam, but were not detected (the non-detected group) is that all fish have equal probability of detection. However, Snake River fall Chinook salmon that pass detection sites during winter, when juvenile bypass facilities are shut down, have no chance of detection; thus a critical assumption of the model is violated. Unless or until we are able to determine the number of fish that migrate during this time period, we are unlikely to find appropriate adjustments to the model to produce reasonably accurate estimates of the number of these treatment fish that survive the downstream migration.

Without the ability to reliably estimate the number of fish in the non-detected group, we can neither calculate nor estimate a reliable SAR for this group. Consequently, we cannot compare SARs of the non-detected inriver migrant group to those of a transport group, as is commonly done in transport evaluations of spring/summer Chinook salmon and steelhead.

To further complicate matters, we began noticing that subyearling Chinook salmon that ceased migration during winter and were detected the following spring (after juvenile bypass facilities were watered up) were returning at much higher rates (18-30 times higher) than fish that migrated during summer of the same year they were released. Thus, in addition to being unable to estimate the number of non-detected fish, which forms the inriver migrant group for comparison, we found that these same fish have been adding disproportionately to the total number of returning adults. When we consider that adult returns of detected subyearlings are higher for fish that migrated as juveniles later in the year, our estimate of the total number of non-detected juvenile inriver migrants is even less meaningful, since we lack any knowledge of juvenile migration timing for "non-detected" adults.

Despite these difficulties, we believed we could compare the SARs of fish returned to the river following detection at Lower Granite Dam to those of transported fish. Fish detected and bypassed are known to have passed during the transport "window" at the dam: once collected, they can potentially be transported. Thus, they provide a basis for comparison to fish collected and transported from the same dam. This comparison addresses the important question for managers, “What do I do with this fish now that I’ve collected it? (i.e., to transport or not)”. However, it does not address other potential effects of transport or comparison with other mitigation strategies, such as passage via spill and use of RSWs, which affect entire populations. This is true of any comparison that excludes the substantial number of fish that are never detected within the hydropower system.

In addition, it could be argued that detections of subyearling Chinook bypassed at Lower Granite Dam do not constitute an unbiased data set for comparison with transported fish because we do not know whether these fish continued to migrate downstream after detection and bypass. Evidence of migration cessation was found in data from our 2002-2004 study years, where a number of fish were detected as subyearlings during their expected juvenile migration year (the same year as release), but were subsequently detected as yearling migrants the following year. So far, these detections indicate only that fish may delay migration anywhere along the migration corridor. For example, one fish was detected as a subyearling at Lower Granite Dam in June 2002 and then as a yearling the following spring at Little Goose Dam; thus it remained in the upper Snake River for months after detection.

In response to this new information, we changed our study design in 2005 (Connor et al. 2008). For fish released during transport studies prior to implementation of the new study design (2001-2004), we can estimate SARs only for fish groups known to have passed Lower Granite Dam. These include the transport group (transported from the dam), a "bypass" group (detected and bypassed at the dam), and a "holdover" group (detected at or below the dam in the spring following release).

Since 2002, we have also PIT-tagged fish in the fall to develop an index of SARs for subyearling Chinook transported during the fall migration season. Adult returns from these releases will be used to evaluate whether truck transport had any obvious detriments to fish. However, we did not release an inriver migrant cohort with the fall transport groups until 2007. Therefore, we cannot compare transport of these index fish directly as a potential alternative to bypassing collected fish to the tailrace.

Smolt-to-adult returns from our 2004 release did nothing to alter the conclusion of Williams et al. (2005), that based on comparison of transported and bypassed groups, transportation appeared to neither greatly harm nor help Snake River fall Chinook salmon. Transported fish had higher SARs than bypassed fish in 2004, although we could not determine if there was any significance to this as the number of adults in both groups was very small. The highest SARs were observed in the holdover group. We expected that fish in the holdover group would have higher SARs as they were substantially larger than fish that migrated a year earlier.

We expected that conversion rates from Bonneville Dam to Lower Granite Dam would be lower, in general, for fall Chinook salmon adults than for spring/summer Chinook salmon adults due to the higher harvest rate for fall Chinook salmon. However, we continue to be surprised at the extremely low conversion rate of adults from the fall transport index groups. For fall transport index fish released in 2004, the overall conversion rate (54.0%) was higher than either 2002 (51.0%) or 2003 (40%). Nevertheless, the 2004 transport index group was still the poorest performing group in terms of conversion rate from Bonneville Dam to Lower Granite Dam.

During fall 2005-2008, returning adults from the 2002 and 2003 transport study years were captured at Lower Granite Dam trap (Harmon 2003) as part of a life-history study (Marsh et al. 2007; in prep). Fish were diverted to the trap using the separation-by-code PIT-tag diversion system (Marsh et al. 1999; Downing et al. 2001). Lengths of the returning adults from fall transport group of the 2002 study year (Table 12) supported the idea that fall transport adults are larger than the other groups. However, adults from the fall transport group of 2003 did not show this. We are awaiting scale analysis results from the 2007 and 2008 adult return years which will provide us with information on adult size for the 2004 outmigration.

Table 12. Average lengths of adult hatchery and river-run fall Chinook salmon PIT-tagged as juveniles in 2002-2004 and re-captured at Lower Granite Dam during fall 2005-2008 (not all 2007 and 2008 scales have been analyzed). Because of the low number of adults from 2003 and 2004 study years, groups are broken into holdover, fall transport, and all other adults.

Age class	Migration history	Number of adults	Average length of returning adults at Lower Granite Dam (mm)
2002 study year			
Age-3-ocean	Bypass	4	733.3
	Transport	23	739.3
	Holdover	12	712.5
	Fall transport index	24	748.5
Age-4-ocean	Bypass	2	805.0
	Transport	8	840.0
	Holdover	1	820.0
	Fall transport index	9	848.8
2003 study year			
Age-2-ocean	Bypass/Transport	9	667.8
	Holdover	0	--
	Fall transport index	15	652.7
Age-3-ocean	Bypass/Transport	2	820.0
	Holdover	1	780.0
	Fall transport index	14	840.0
Age-4-ocean	Bypass/Transport	2	950.0
	Holdover	0	--
	Fall transport index	5	880.0
2004 study year			
Age-2-ocean	Bypass/Transport	1	620.0
	Holdover	2	595.0
	Fall transport index	12	624.2
Age-3-ocean	Bypass/Transport	3	803.3
	Holdover	1	820.0
	Fall transport index	10	787.0
Age-4-ocean	Bypass/Transport	3	930.0
	Holdover	2	870.0
	Fall transport index	4	955.0

One confounding issue when discussing size at juvenile migration and size of returning adults is whether the fish entered the ocean as a subyearling or as a yearling. One would expect that adults from the holdover group would also be larger adults because they were larger when they migrated as juveniles, and if ocean age was assigned based on time at sea, that would be the case. However, in transport studies, we assign ocean age based on brood year. Therefore, adults that delayed migration until the spring following release have actually spent one less year at sea than their cohorts of the same age class. Growth occurs more rapidly during ocean residence; therefore, fish that spend less time in the ocean, return at smaller sizes.

Nevertheless, we continue to assign ages in this manner, and our reason for doing so is based on another surprising finding from the life history study: Analysis of scales taken from returning adults has shown that a large proportion of adults from the fall transport index group had overwintered in freshwater areas below Bonneville Dam after being transported. Thus these fish entered the ocean as yearlings, as did fish in the holdover group. If age assignment was based on time at sea instead of brood year, we would need two fall transport index groups: one that entered the ocean as subyearlings and a second that entered as yearlings/holdovers. In fact, as Table 13 shows, the fall transport group is not the only group from the 2002 and 2003 study years that has a mixture of subyearling and yearling ocean entrants, and would require this treatment. At present, we avoid confusion by continuing to assign ocean age based on brood year.

Table 13. Age at ocean entry for adult hatchery and river-run fall Chinook salmon PIT-tagged as juveniles at for transport studies in 2002 and 2003 and re-captured at Lower Granite Dam during falls of 2005-2008 (not all 2007 and 2008 scales have been analyzed).

		Age at ocean entry		
Age class	Migration history	Subyearling	Yearling	Unknown
2002 Study year				
Age-3-ocean	Bypass	3	0	0
	Transport	7	5	3
	Holdover	0	8	0
	Fall transport index	1	9	3
Age-4-ocean	Bypass	0	0	0
	Transport	3	2	1
	Holdover	0	1	0
	Fall transport index	1	5	2
2003 Study year				
Age-2-ocean	Bypass	1	1	0
	Transport	4	0	0
	Holdover	0	0	0
	Fall transport index	7	6	2
Age-3-ocean	Bypass	0	0	0
	Transport	0	0	0
	Holdover	0	1	0
	Fall transport index	10	7	1
Age-4-ocean	Bypass	0	0	0
	Transport	0	0	0
	Holdover	0	0	0
	Fall transport index	2	0	0
2004 Study year				
Age-2-ocean	Bypass	2	0	0
	Transport	0	0	0
	Holdover	0	2	0
	Fall transport index	3	9	0
Age-3-ocean	Bypass	0	0	4
	Transport	0	0	0
	Holdover	0	1	0
	Fall transport index	3	2	7
Age-4-ocean	Bypass	0	0	0
	Transport	2	0	2
	Holdover	0	1	1
	Fall transport index	0	3	2

ACKNOWLEDGEMENTS

We thank the U.S. Army Corps of Engineers (USACE) for their assistance with this study. We thank personnel, especially Dave Marvin, of the Pacific States Marine Fisheries Commission who operate and maintain the Columbia Basin PIT-tag Information System. Thanks also to the staff from the Lower Granite Dam Smolt Monitoring Program for providing fish for this study.

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APPENDIX A

Juvenile Data from the 2004 Fall Chinook Salmon Tagging Year

Appendix Table A1. Total river-run fall Chinook salmon tagged at Lower Granite Dam in June and July 2004.

	Transport		Inriver					
Tag date	Tag number	Mean fork length (mm)	Tag number	Mean fork length (mm)	Mortalities	Lost tags	Release number*	Mean fork length (mm)
6/2/04	35	103.3	483	102.2	5	0	478	102.2
6/3/04	14	98.8	348	104.1	18	0	330	104.0
6/4/04	25	105.3	491	100.7	20	0	471	100.9
6/7/04	108	104.3	2,066	104.0	17	0	2,049	103.9
6/8/04	69	102.6	3,683	103.6	17	2	3,664	103.6
6/9/04	75	101.2	2,335	108.8	15	0	2,320	108.7
6/10/04	103	101.5	2,743	103.3	8	0	2,735	103.3
6/14/04	453	101.6	2,559	101.4	3	1	2,555	101.4
6/15/04	208	101.6	3,025	101.5	1	0	3,024	101.5
6/16/04	264	101.5	3,015	102.0	5	0	3,010	102.0
6/17/04	259	103.2	2,952	103.5	32	2	2,918	103.5
6/18/04	93	103.4	1,240	103.8	1	2	1,237	103.9
6/21/04	233	103.3	3,042	104.5	3	2	3,037	104.5
6/22/04	250	104.2	3,129	104.5	12	3	3,114	104.5
6/23/04	255	105.1	3,205	104.0	20	1	3,184	104.0
6/24/04	99	104.3	1,252	104.1	11	3	1,238	104.2
6/25/04	144	102.8	1,828	102.7	3	0	1,825	102.7
6/28/04	211	107.0	840	106.8	17	4	819	106.8
6/29/04	191	105.9	757	106.8	5	1	751	106.8
6/30/04	151	106.7	841	107.3	6	1	834	107.3
7/1/04	31	103.9	466	102.8	11	2	453	102.9
7/2/04	25	102.9	368	104.5	4	6	358	104.4
7/6/04	19	102.3	294	101.7	5	2	287	101.9
7/7/04	19	100.3	284	100.9	7	1	276	101.1
7/8/04	17	101.1	259	101.4	4	2	253	101.5
7/9/04	20	101.9	302	98.8	4	0	298	98.9
7/12/04	20	101.8	300	101.9	0	3	297	101.9
7/13/04	20	101.6	302	101.5	6	2	294	101.6
7/14/04	20	106.5	293	104.2	1	2	290	104.2
7/15/04	20	99.6	301	103.3	1	5	295	103.2
7/16/04	13	104.7	202	103.8	3	3	196	103.6
7/19/04	20	105.6	303	104.2	3	4	296	104.3
7/20/04	19	107.4	284	105.6	4	8	272	105.5
7/21/04	12	107.9	195	109.2	2	4	189	109.2
7/22/04	11	106.2	188	112.4	3	5	180	112.2
7/23/04	5	108.8	93	113.2	1	0	92	112.9
7/26/04	21	116.0	300	111.5	0	6	294	111.3
7/27/04	15	118.0	249	114.6	3	2	244	114.6
7/28/04	17	111.6	281	114.7	0	2	279	114.6
7/29/04	18	115.8	269	116.5	1	1	267	116.5
7/30/04	20	117.3	298	117.2	3	2	293	117.3

Appendix Table A2. Total river-run fall Chinook salmon PIT-tagged at Lower Granite Dam during fall 2004.

	Tagged at, and transported from, Lower Granite Dam				
Tag Date	Tagged	Mortalities	Lost tags	Duplicates	Released
15 Sep 04	101	-	-	-	101
17 Sep 04	330	-	-	-	330
21 Sep 04	321	-	-	-	321
23 Sep 04	250	-	-	-	250
29 Sep 04	110	-	-	-	110
1 Oct 04	41	-	-	-	41
5 Oct 04	117	-	-	-	117
7 Oct 04	242	-	-	-	242
13 Oct 04	126	-	1	-	125
15 Oct 04	123	-	-	-	123
19 Oct 04	152	-	-	-	152
21 Oct 04	146	-	-	-	146
27 Oct 04	326	-	-	-	326
29 Oct 04	160	-	-	-	160

Appendix Table A3. Locations of observations (detections) of PIT-tagged juvenile fall Chinook salmon within the Little Goose Dam juvenile fish facility, 2004 study year.

	Detected once at Lower Granite Dam (coil location)				Detected on separator and at least one additional coil (coil location)			
Detection date	Separator	Diversion	Sample	Raceway	Diversion	Sample	Raceway	Sample diversion
6/5/04	-	-	-	-	125	2	-	-
6/6/04	-	-	-	-	417	4	-	-
6/7/04	-	-	-	-	300	6	1	-
6/8/04	-	-	-	-	71	1	1	-
6/9/04	-	-	-	-	34	-	-	-
6/10/04	1	-	-	-	932	14	-	-
6/11/04	6	1	-	2	1,494	19	2	-
6/12/04	6	-	-	-	1,433	13	3	-
6/13/04	1	-	-	1	1,187	21	3	-
6/14/04	2	-	-	-	470	12	348	-
6/15/04	2	-	-	-	95	12	346	-
6/16/04	1	-	-	1	50	5	188	-
6/17/04	-	-	-	-	34	4	126	-
6/18/04	-	-	-	-	55	16	170	-
6/19/04	7	-	-	-	164	27	621	-
6/20/04	14	-	-	-	381	70	1,435	-
6/21/04	9	-	-	1	348	62	985	-
6/22/04	10	-	1	-	295	45	767	1
6/23/04	5	-	-	-	148	21	347	-
6/24/04	2	1	-	-	182	17	450	-
6/25/04	10	-	-	2	311	65	832	-
6/26/04	33	-	-	-	526	34	1,554	-
6/27/04	45	-	-	1	723	64	2,112	-
6/28/04	4	2	-	2	306	29	930	-
6/29/04	9	-	-	-	232	25	846	-
6/30/04	2	-	-	-	152	20	537	-
7/1/04	8	1	-	-	165	29	542	-
7/2/04	2	-	-	-	179	27	671	-
7/3/04	2	-	-	-	102	19	409	-
7/4/04	2	-	-	-	52	16	187	-
7/5/04	-	-	-	-	28	13	102	-
7/6/04	-	-	-	-	30	18	115	-
7/7/04	2	-	-	-	45	26	155	-
7/8/04	1	-	-	-	30	12	128	-
7/9/04	-	-	-	-	5	6	20	-
7/10/04	-	-	-	-	9	11	30	-
7/11/04	-	-	-	-	7	4	20	-
7/12/04	-	-	-	-	8	14	15	-
7/13/04	1	-	-	-	11	16	28	-
7/14/04	-	-	-	-	12	13	33	-
7/15/04	2	-	-	-	12	5	44	-
7/16/04	-	-	-	-	9	5	27	-
7/17/04	1	-	-	-	18	18	57	-
7/18/04	-	-	-	-	17	11	56	-
7/19/04	1	-	-	-	17	6	53	-
7/20/04	-	-	-	-	5	3	21	-

Appendix Table A3. Continued.

Detection date	Detected once at Lower Granite Dam (coil location)				Detected on separator and at least one additional coil (coil location)			
	Separator	Diversion	Sample	Raceway	Diversion	Sample	Raceway	Sample diversion
7/21/04	-	-	-	-	4	2	13	-
7/22/04	-	-	-	-	13	25	23	-
7/23/04	6	-	-	-	16	31	35	-
7/24/04	1	-	-	-	8	11	15	-
7/25/04	-	-	-	-	3	1	10	-
7/26/04	-	-	-	-	3	6	8	-
7/27/04	-	-	-	-	7	14	12	-
7/28/04	-	-	-	-	5	21	4	-
7/29/04	2	-	-	-	4	11	2	-
7/30/04	3	-	-	-	7	12	7	-
7/31/04	1	-	-	-	4	14	2	-
8/1/04	-	-	-	-	8	22	6	-
8/2/04	1	-	-	-	6	14	8	-
8/3/04	-	-	-	-	7	26	7	-
8/4/04	2	-	-	-	17	36	14	-
8/5/04	-	-	1	-	13	29	31	-
8/6/04	3	-	-	-	18	38	31	-
8/7/04	-	-	-	-	13	21	24	-
8/8/04	-	-	-	-	8	12	26	-
8/9/04	-	-	-	-	7	9	19	-
8/10/04	-	-	-	-	3	8	7	-
8/11/04	-	-	-	-	4	9	8	-
8/12/04	-	-	-	-	3	12	4	-
8/13/04	-	-	-	-	4	13	3	-
8/14/04	-	-	-	-	2	6	-	-
8/15/04	-	-	-	-	1	2	3	-
8/16/04	-	-	-	-	-	2	-	-
8/17/04	-	-	-	-	4	15	-	-
8/18/04	1	-	-	-	6	19	-	-
8/19/04	1	-	-	-	3	12	-	-
8/20/04	-	-	-	-	3	6	-	-
8/21/04	-	-	-	-	1	1	-	-
8/22/04	-	-	-	-	1	4	-	-
8/23/04	-	-	-	-	2	7	-	-
8/24/04	-	-	-	-	4	16	-	-
8/25/04	-	-	-	-	7	11	17	-
8/26/04	-	-	-	-	7	9	17	-
8/27/04	1	-	-	-	2	6	5	-
8/28/04	-	-	-	-	4	13	1	-
8/29/04	-	-	-	-	1	4	-	-
8/30/04	-	-	-	-	-	2	-	-
8/31/04	-	-	-	-	1	6	-	-
9/1/04	-	-	-	-	1	2	-	-
9/2/04	-	-	-	-	2	9	-	-
9/3/04	-	-	-	-	1	3	-	-
9/4/04	-	-	-	-	-	3	-	-
9/5/04	-	-	-	-	1	1	-	-

Appendix Table A3. Continued.

Detection date	Detected once at Lower Granite Dam (coil location)				Detected on separator and at least one additional coil (coil location)			
	Separator	Diversion	Sample	Raceway	Diversion	Sample	Raceway	Sample diversion
9/6/04	-	-	-	-	1	4	-	-
9/7/04	-	-	-	-	1	7	-	-
9/8/04	-	-	-	-	2	3	-	-
9/9/04	-	-	-	-	2	10	-	-
9/10/04	1	-	-	-	4	16	-	-
9/11/04	-	-	-	-	1	5	-	-
9/12/04	-	-	-	-	1	6	-	-
9/13/04	-	-	-	-	3	10	-	-
9/14/04	-	-	-	-	2	3	-	-
9/15/04	-	-	-	-	2	11	-	-
9/16/04	-	-	-	-	2	8	-	-
9/17/04	-	-	-	-	2	7	-	-
9/18/04	-	-	-	-	1	4	-	-
9/19/04	-	-	-	-	1	5	-	-
9/20/04	-	-	-	-	1	2	-	-
9/21/04	1	-	-	-	-	1	-	-
9/22/04	-	-	-	-	-	1	-	-
9/23/04	-	-	-	-	1	1	-	-
9/24/04	-	-	-	-	1	3	-	-
9/25/04	-	-	-	-	-	1	-	-
9/26/04	-	-	-	-	-	4	-	-
9/27/04	1	-	-	-	1	4	-	-
9/28/04	-	-	-	-	1	4	-	-
9/29/04	-	-	-	-	1	2	-	-
9/30/04	-	-	-	-	1	1	-	-
10/1/04	-	-	-	-	-	4	-	-
10/2/04	-	-	-	-	1	1	-	-
10/3/04	-	-	-	-	1	2	-	-
10/4/04	-	-	-	-	1	3	-	-
10/5/04	-	-	-	-	-	1	-	-
10/6/04	-	-	-	-	-	4	-	-
10/7/04	-	-	-	-	1	2	-	-
10/8/04	-	-	-	-	1	2	-	-
10/11/04	-	-	-	-	1	3	-	-
10/13/04	-	-	-	-	-	1	-	-
10/14/04	-	-	-	-	1	2	-	-
10/15/04	-	-	-	-	-	2	-	-
10/16/04	-	-	-	-	1	-	-	-
10/17/04	-	-	-	-	1	3	-	-
10/18/04	-	-	-	-	-	-	1	-
10/19/04	-	-	-	-	-	1	-	-
10/20/04	-	-	-	-	1	1	-	-
10/21/04	-	-	-	-	-	3	-	-
10/22/04	-	-	-	-	1	4	-	-
10/23/04	-	-	-	-	1	1	2	-
10/24/04	-	-	-	-	-	1	-	-
10/25/04	-	-	-	-	1	-	-	-

Appendix Table A3. Continued.

Detection date	Detected once at Lower Granite Dam (coil location)				Detected on separator and at least one additional coil (coil location)			
	Separator	Diversion	Sample	Raceway	Diversion	Sample	Raceway	Sample diversion
10/26/04	-	-	-	-	-	-	3	-
10/27/04	-	-	-	-	-	1	-	-
10/28/04	-	-	-	-	1	-	-	-
10/31/04	-	-	-	-	-	1	-	-
11/2/04	1	-	-	-	-	-	-	-
11/3/04	1	-	-	-	-	-	-	-
4/4/05	-	-	-	-	1	-	-	-
4/6/05	-	-	-	-	1	-	-	-
4/7/05	-	-	-	-	1	-	-	-
4/8/05	-	-	-	-	2	-	-	-
4/11/05	-	-	-	-	2	-	-	-
4/13/05	-	-	-	-	1	-	-	-
4/14/05	-	-	-	-	4	-	-	-
4/15/05	-	-	-	-	3	-	-	-
4/16/05	-	-	-	-	10	-	-	-
4/17/05	-	-	-	-	5	-	-	-
4/18/05	-	-	-	-	4	-	-	-
4/19/05	-	-	-	-	4	-	-	-
4/20/05	-	-	-	-	3	-	-	-
4/21/05	-	-	-	-	3	-	-	-
4/22/05	-	-	-	-	1	-	-	-
4/24/05	-	-	-	-	3	-	-	-
4/25/05	-	-	-	-	1	-	-	-
4/26/05	-	-	-	-	2	-	-	-
4/27/05	-	-	-	-	3	-	-	-
4/28/05	-	-	-	-	6	-	-	-
4/29/05	-	-	-	-	1	-	-	-
4/30/05	-	-	-	-	1	-	-	-
5/1/05	-	-	-	-	3	-	-	-
5/2/05	-	-	-	-	4	-	-	-
5/3/05	-	-	-	-	1	-	-	-
5/9/05	-	-	-	-	1	-	-	-

Appendix Table A4. Locations of observations (detections) of PIT-tagged juvenile fall Chinook salmon within the Lower Monumental Dam juvenile fish facility, 2004 study year.

Detection date	Detected once at Little Goose Dam (coil location)			Detected on separator and one additional coil (coil location)			
	Separator	Diversion	Raceway	Diversion	Sample	River	Raceway
6/6/04	-	-	-	25	1	-	-
6/7/04	1	1	-	147	7	-	3
6/8/04	4	-	-	198	8	-	4
6/9/04	2	-	-	173	4	-	-
6/10/04	-	-	1	46	-	-	1
6/11/04	1	-	-	119	4	-	4
6/12/04	1	-	-	345	14	-	8
6/13/04	2	-	-	527	21	-	3
6/14/04	5	-	-	337	30	-	262
6/15/04	3	-	-	126	26	-	378
6/16/04	11	-	-	84	21	-	219
6/17/04	1	1	-	78	19	-	153
6/18/04	4	-	-	32	20	-	94
6/19/04	3	-	-	49	9	-	79
6/20/04	2	-	-	18	2	-	65
6/21/04	-	-	-	21	2	-	71
6/22/04	2	-	-	53	10	-	131
6/23/04	7	-	-	32	12	-	81
6/24/04	17	-	-	56	96	-	61
6/25/04	7	-	-	27	36	-	25
6/26/04	14	-	-	50	100	-	54
6/27/04	28	-	-	72	99	-	62
6/28/04	17	-	-	69	63	-	132
6/29/04	11	-	-	90	124	-	109
6/30/04	2	-	-	117	34	-	295
7/1/04	-	-	-	102	15	-	218
7/2/04	1	-	-	55	13	-	99
7/3/04	-	-	-	33	14	-	118
7/4/04	-	-	-	16	8	-	43
7/5/04	1	-	-	15	29	-	13
7/6/04	1	-	-	25	50	-	23
7/7/04	-	-	-	19	26	-	23
7/8/04	-	-	-	60	19	-	47
7/9/04	-	-	-	25	13	-	51
7/10/04	-	-	-	14	19	-	32
7/11/04	-	-	-	11	14	-	20
7/12/04	-	-	-	29	25	-	93
7/13/04	1	-	-	23	20	-	73
7/14/04	-	-	-	7	6	-	33

Appendix Table A4. Continued.

Detection date	Detected once at Little Goose Dam (coil location)			Detected on separator and one additional coil (coil location)			
	Separator	Diversion	Raceway	Diversion	Sample	River	Raceway
7/15/04	-	-	-	14	10	-	42
7/16/04	-	-	-	7	4	-	21
7/17/04	-	-	-	10	12	-	22
7/18/04	-	-	-	9	6	-	22
7/19/04	-	-	-	4	2	-	20
7/20/04	-	-	-	6	-	-	12
7/21/04	-	-	-	1	-	-	5
7/22/04	-	-	-	-	1	-	4
7/23/04	-	-	-	2	1	-	2
7/24/04	-	-	-	2	1	-	8
7/25/04	-	-	-	2	-	-	9
7/26/04	-	-	-	2	1	-	7
7/27/04	-	-	-	3	5	-	5
7/28/04	-	-	-	2	4	-	4
7/29/04	-	-	-	1	2	-	3
7/30/04	-	-	-	2	2	-	3
7/31/04	-	-	-	3	3	-	7
8/1/04	-	-	-	1	4	-	2
8/2/04	-	-	-	1	2	-	2
8/3/04	-	-	-	1	2	1	4
8/4/04	-	-	-	1	-	-	3
8/5/04	-	-	-	2	1	-	4
8/6/04	-	-	-	2	4	-	4
8/7/04	-	-	-	4	5	-	10
8/8/04	-	-	-	3	2	-	7
8/9/04	-	-	-	1	1	-	7
8/10/04	-	-	-	2	2	-	3
8/11/04	-	-	-	-	-	-	1
8/12/04	-	-	-	1	1	-	2
8/13/04	-	-	-	-	1	-	1
8/14/04	-	-	-	-	-	-	2
8/15/04	-	-	-	1	-	-	-
8/16/04	-	-	-	-	3	-	3
8/17/04	-	-	-	1	6	-	-
8/18/04	-	-	-	3	8	-	-
8/19/04	-	-	-	1	4	-	-
8/20/04	-	-	-	1	6	-	-
8/21/04	-	-	-	1	5	-	-
8/22/04	-	-	-	2	9	-	-

Appendix Table A4. Continued.

Detection date	Detected once at Little Goose Dam (coil location)			Detected on separator and one additional coil (coil location)			
	Separator	Diversion	Raceway	Diversion	Sample	River	Raceway
8/23/04	1	-	-	1	5	-	-
8/24/04	-	-	-	1	4	-	-
8/25/04	-	-	-	4	14	-	-
8/26/04	-	-	-	2	6	-	-
8/27/04	-	-	-	1	5	-	-
8/28/04	-	-	-	3	7	-	-
8/29/04	-	-	-	2	12	-	-
8/30/04	2	-	-	2	5	-	-
9/2/04	-	-	-	-	1	-	-
9/5/04	-	-	-	-	2	-	-
9/9/04	2	-	-	2	-	-	-
9/10/04	-	-	-	1	1	-	-
9/11/04	-	-	-	1	4	-	-
9/12/04	-	-	-	1	1	-	-
9/13/04	-	-	-	2	2	-	-
9/14/04	-	-	-	-	1	-	-
9/15/04	-	-	-	-	2	-	-
9/16/04	-	-	-	-	2	-	-
9/17/04	-	-	-	1	1	-	-
9/18/04	-	-	-	1	2	-	-
9/19/04	-	-	-	1	2	-	-
9/24/04	-	-	-	-	2	-	-
9/26/04	-	-	-	1	2	-	-
9/30/04	-	-	-	1	-	-	-
4/1/05	-	-	-	1	-	-	-
4/2/05	-	-	-	4	2	-	-
4/3/05	-	-	-	4	1	-	-
4/4/05	-	-	-	2	-	-	-
4/5/05	-	-	-	1	-	-	-
4/6/05	-	-	-	-	1	-	-
4/7/05	-	-	-	4	-	-	-
4/9/05	-	-	-	3	-	-	-
4/10/05	-	-	-	2	-	-	-
4/11/05	-	-	-	2	-	-	-
4/12/05	-	-	-	1	-	-	-
4/13/05	-	-	-	3	-	-	-
4/14/05	-	-	-	1	1	-	-
4/15/05	-	-	-	1	-	-	-
4/16/05	-	-	-	1	-	-	-

Appendix Table A4. Continued.

Detection date	Detected once at Little Goose Dam (coil location)			Detected on separator and one additional coil (coil location)			
	Separator	Diversion	Raceway	Diversion	Sample	River	Raceway
4/19/05	-	-	-	1	-	-	-
4/20/05	-	-	-	5	-	-	-
4/21/05	-	-	-	2	-	-	-
4/22/05	-	-	-	5	-	-	-
4/23/05	-	-	-	5	-	-	-
4/24/05	-	-	-	4	-	-	-
4/25/05	-	-	-	1	-	-	-
4/26/05	-	-	-	2	-	-	-
4/27/05	-	-	-	5	-	-	-
4/28/05	-	-	-	2	-	-	-
4/29/05	-	-	-	5	-	-	-
4/30/05	-	-	-	1	-	-	2
5/1/05	-	-	-	4	-	-	-
5/2/05	-	-	-	4	-	-	1
5/4/05	-	-	-	1	-	-	-
5/5/05	-	-	-	1	-	-	1
5/7/05	-	-	-	2	-	-	-
5/8/05	-	-	-	2	-	-	-
5/9/05	-	-	-	2	-	-	-
5/10/05	-	-	-	1	-	-	-
5/11/05	-	-	-	1	-	-	-
5/13/05	-	-	-	1	-	-	-

Appendix Table A5. Locations of observations(detections) of PIT-tagged fall Chinook salmon within the McNary Dam juvenile fish facility, 2004 study year.

			Detected on full-flow and additional coil(s) (coil location)						
				Detected on separator and additional coil(s) (coil location)					
MCJ date	Full-flow	Separator	Diversion	Diversion	Sample	Raceway	Sample diversion	Diversion	Raceway
6/8/04	2	-	-	-	-	-	-	-	-
6/9/04	3	-	-	4	-	-	-	-	-
6/10/04	26	-	-	4	-	-	-	-	-
6/11/04	17	-	1	57	-	-	1	-	-
6/12/04	80	-	-	19	-	-	-	-	-
6/13/04	16	-	-	25	-	-	-	2	-
6/14/04	35	-	-	6	-	-	-	-	-
6/15/04	20	-	-	91	-	-	7	1	-
6/16/04	122	-	-	20	-	-	-	-	-
6/17/04	36	-	1	92	-	-	1	-	-
6/18/04	122	-	-	38	-	-	-	-	-
6/19/04	92	-	-	50	-	-	1	-	-
6/20/04	161	-	-	-	-	-	-	-	-
6/21/04	24	-	-	56	-	-	1	-	-
6/22/04	56	-	-	-	-	-	-	-	-
6/23/04	39	-	-	22	-	33	-	-	-
6/24/04	1	-	-	31	4	116	-	-	-
6/25/04	19	-	-	22	-	70	-	-	-
6/26/04	22	-	-	13	1	41	-	-	-
6/27/04	-	-	-	42	-	114	-	-	-
6/28/04	2	-	-	50	-	150	-	-	-
6/29/04	3	-	-	56	2	131	-	-	-
6/30/04	9	-	-	31	-	75	-	-	-
7/1/04	10	-	-	40	1	76	-	-	-
7/2/04	1	-	-	53	-	103	-	-	-
7/3/04	2	1	-	65	2	150	-	-	-
7/4/04	1	-	-	46	-	118	-	-	-

Appendix Table A5. Continued.

			Detected on full-flow and additional coil(s) (coil location)						
				Detected on separator and additional coil(s) (coil location)					
MCJ date	Full-flow	Separator	Diversion	Diversion	Sample	Raceway	Sample diversion	Diversion	Raceway
7/5/04	6	-	-	54	1	113	-	-	-
7/6/04	2	-	-	29	1	78	-	-	-
7/7/04	2	-	-	20	-	33	-	-	-
7/8/04	3	-	-	14	-	32	-	-	-
7/9/04	3	-	-	16	-	32	-	-	1
7/10/04	-	-	-	11	-	35	-	-	-
7/11/04	-	-	-	17	1	39	-	-	-
7/12/04	9	-	-	22	-	65	-	-	-
7/13/04	5	-	-	27	4	67	-	-	-
7/14/04	7	-	-	22	1	53	-	-	-
7/15/04	3	-	-	13	1	38	-	-	-
7/16/04	7	-	-	18	1	45	-	-	-
7/17/04	1	-	-	14	3	49	-	-	-
7/18/04	2	-	-	10	1	25	-	-	-
7/19/04	3	-	-	7	2	20	-	-	-
7/20/04	1	-	-	4	2	14	-	-	-
7/21/04	1	-	-	5	2	19	-	-	-
7/22/04	1	-	-	9	3	15	-	-	-
7/23/04	3	-	-	2	3	12	-	-	-
7/24/04	-	-	-	3	1	9	-	-	-
7/25/04	1	-	-	6	1	9	-	-	-
7/26/04	-	-	-	2	-	8	-	-	-
7/27/04	-	-	-	-	-	6	-	-	-
7/28/04	-	-	-	1	-	4	-	-	-
7/29/04	1	-	-	2	-	1	-	-	-
7/30/04	2	-	-	-	-	3	-	-	-
7/31/04	1	-	-	-	-	-	-	-	-
8/1/04	-	-	-	2	-	5	-	-	-
8/2/04	-	-	-	1	-	1	-	-	-

Appendix Table A5. Continued.

			Detected on full-flow and additional coil(s) (coil location)						
				Detected on separator and additional coil(s) (coil location)					
MCJ date	Full-flow	Separator	Diversion	Diversion	Sample	Raceway	Sample diversion	Diversion	Raceway
8/3/04	1	-	-	-	-	2	-	-	-
8/4/04	1	-	-	-	-	2	-	-	-
8/5/04	-	-	-	-	-	3	-	-	-
8/6/04	1	-	-	1	-	-	-	-	-
8/7/04	-	-	-	-	-	1	-	-	-
8/8/04	1	-	-	-	-	1	-	-	-
8/9/04	2	-	-	-	1	1	-	-	-
8/10/04	2	-	-	1	-	-	-	-	-
8/11/04	-	-	-	2	-	4	-	-	-
8/12/04	-	-	-	-	-	1	-	-	-
8/13/04	1	-	-	1	-	-	-	-	-
8/14/04	1	-	-	-	-	1	-	-	-
8/15/04	-	-	-	-	-	3	-	-	-
8/16/04	-	-	-	-	-	1	-	-	-
8/17/04	1	-	-	-	-	-	-	-	-
8/19/04	1	-	-	-	1	-	-	-	-
8/20/04	1	-	-	-	-	-	-	-	-
8/23/04	-	-	-	1	-	-	-	-	-
8/24/04	4	-	-	-	1	2	-	-	-
8/25/04	2	-	-	2	-	2	-	-	-
8/26/04	-	-	-	-	-	3	-	-	-
8/27/04	-	-	-	1	-	2	-	-	-
8/28/04	2	-	-	-	-	3	-	-	-
8/29/04	1	-	-	1	2	3	-	-	-
8/30/04	2	-	-	1	-	2	-	-	-
8/31/04	2	-	-	-	1	1	-	-	-
9/1/04	5	-	-	-	-	-	-	-	-
9/2/04	-	-	-	1	-	-	-	-	-
9/3/04	1	-	-	-	-	1	-	-	-

Appendix Table A5. Continued.

			Detected on full-flow and additional coil(s) (coil location)						
				Detected on separator and additional coil(s) (coil location)					
MCJ date	Full-flow	Separator	Diversion	Diversion	Sample	Raceway	Sample diversion	Diversion	Diversion
9/5/04	-	-	-	-	-	1	-	-	-
9/6/04	1	-	-	-	-	-	-	-	-
9/7/04	1	-	-	-	1	-	-	-	-
9/8/04	-	-	-	-	-	1	-	-	-
9/9/04	2	-	-	-	-	-	-	-	-
9/10/04	1	-	-	-	1	1	-	-	-
9/11/04	1	-	-	-	-	-	-	-	-
9/13/04	-	-	-	1	-	-	-	-	-
9/15/04	1	-	-	-	-	-	-	-	-
9/18/04	1	-	-	-	-	-	-	-	-
9/19/04	1	-	-	-	-	-	-	-	-
9/20/04	2	-	-	-	-	-	-	-	-
9/23/04	1	-	-	-	-	-	-	-	-
9/25/04	1	-	-	-	-	-	-	-	-
9/28/04	1	-	-	-	-	-	-	-	-
11/7/04	1	-	-	-	-	-	-	-	-
11/17/04	1	-	-	-	-	-	-	-	-
11/21/04	1	-	-	-	-	-	-	-	-
11/23/04	1	-	-	-	-	-	-	-	-
11/30/04	1	-	-	-	-	-	-	-	-
12/1/04	1	-	-	-	-	-	-	-	-
12/2/04	1	-	-	-	-	-	-	-	-
12/5/04	1	-	-	-	-	-	-	-	-
12/7/04	2	-	-	-	-	-	-	-	-
12/8/04	2	-	-	-	-	-	-	-	-
12/9/04	2	-	-	-	-	-	-	-	-
12/13/04	3	-	-	-	-	-	-	-	-
3/30/05	1	-	-	-	-	-	-	-	-
4/4/05	-	-	-	1	-	-	-	-	-

Appendix Table A5. Continued.

			Detected on full-flow and additional coil(s) (coil location)						
				Detected on separator and additional coil(s) (coil location)					
MCJ date	Full-flow	Separator	Diversion	Diversion	Sample	Raceway	Sample diversion	Diversion	Diversion
4/7/05	1	-	-	-	-	-	-	-	-
4/8/05	-	-	-	1	-	-	-	-	-
4/9/05	1	-	-	-	-	-	-	-	-
4/12/05	-	-	-	3	-	-	1	-	-
4/13/05	2	-	-	-	-	-	-	-	-
4/14/05	2	-	-	-	-	-	-	-	-
4/15/05	-	-	-	1	-	-	-	-	-
4/18/05	-	-	-	1	-	-	-	-	-
4/19/05	1	-	-	-	-	-	-	-	-
4/20/05	-	-	-	-	-	-	1	-	-
4/21/05	4	-	-	-	-	-	-	-	-
4/22/05	1	-	-	5	-	-	-	-	-
4/23/05	2	-	-	-	-	-	-	-	-
4/24/05	-	-	-	1	-	-	1	-	-
4/25/05	3	-	-	-	-	-	-	-	-
4/26/05	1	-	-	1	-	-	-	-	-
4/27/05	1	-	-	-	-	-	-	-	-
4/28/05	1	-	-	2	-	-	-	-	-
4/29/05	5	-	-	1	-	-	-	-	-
4/30/05	3	-	-	1	-	-	-	-	-
5/1/05	1	-	-	-	-	-	-	-	-
5/3/05	1	-	-	-	-	-	-	-	-
5/4/05	1	-	-	-	-	-	-	-	-
5/5/05	1	-	-	-	-	-	-	-	-
5/6/05	-	-	-	1	-	-	-	-	-
5/7/05	1	-	-	1	-	-	-	-	-
5/9/05	2	-	-	-	-	-	-	-	-
5/11/05	-	-	-	1	-	-	-	-	-
5/15/05	1	-	-	-	-	-	-	-	-
5/16/05	-	-	-	1	-	-	-	-	-

APPENDIX B

Adult Returns from Previous and Ongoing Studies

Appendix Table B1. Snake River fall Chinook salmon transport studies.

Tagging year	Juvenile fish numbers			Returns by age-class					SAR			Year of final adult returns	Report
	Transport	Fall Transport[a]	Bypass	Jack	2-ocean	3-ocean	4-ocean	5-ocean	Transport	Fall Transport	Bypass		
2008	311,148	11,265	298,801	--	--	--	--	--	--	--	--	2011	
2007	--na--	8,742	--na--	123	--	--	--	--	--	--	--	2011	
2006[b]	270,639	2,308	220,523	508	662	--	--	--	--	--	--	2010	
2005[b]	84,844	2,545	83,272	80	110	64	--	--	--	--	--	2009	
2004[c]	**3,608**	**2,544**	**8,898**	**27**	**27**	**37**	**20**	**--**	**0.14**	**1.89**	**0.04**	**2008**	**This report**
2003[d]	16,085	2,552	3,962	45	39	30	7	2	0.09	3.84	0.13	2007	Marsh et al (in press)
2002[d]	12,344	2,500	3,990	101	159	64	20	1	0.98	4.88	0.66	2006	Marsh et al. (2008)
2001[d]	18,904	--na--	2,429	33	38	17	7	0	0.23	--	0.28	2006	Marsh et al. (2008)

[a] Beginning in 2007, fish tagged in the fall were split into transport and inriver groups, with inriver fish being released to the Lower Granite Dam tailrace.

[b] These fish were tagged at Dworshak Hatchery as part of either a joint NOAA Fisheries/U. S. Fish and Wildlife Service study or the Regional Consensus Study. Fish were assigned to either a "Transport" or "Bypass" group prior to release.

[c] The Transport and Bypass fish were tagged at Lower Granite Dam from 2 June to 30 July 2004.

[d] Juvenile "Bypass" numbers are raw numbers, not adjusted using the methodology of Sandford & Smith (2002).